

# **Interactive Control of Avatars Animated with Human Motion Data**

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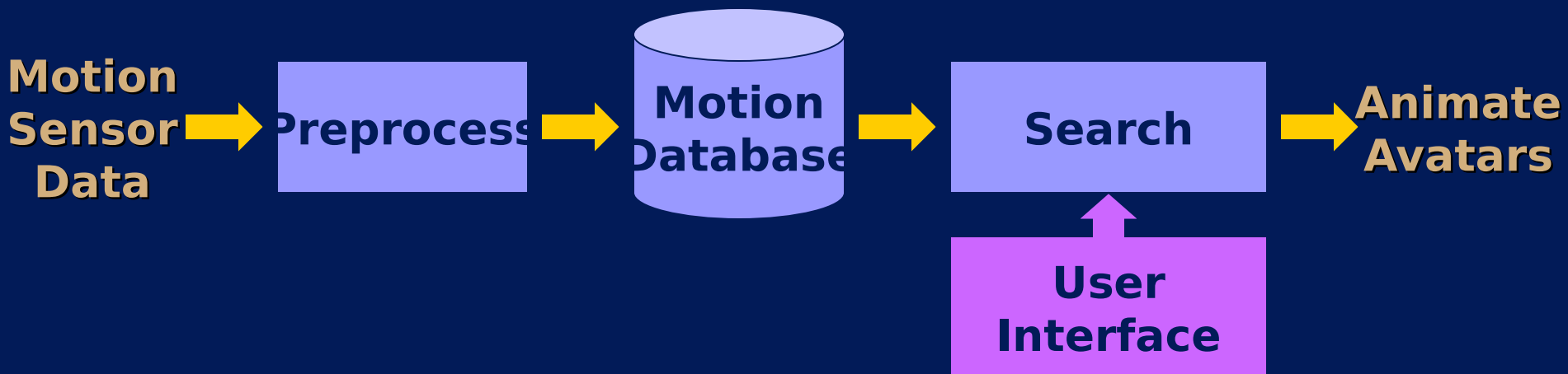
# **Avatars:** Controllable, Responsive Animated Characters

- Realistic behavior
- Non-trivial environment
- Intuitive user interface



# Interactive Avatar Control

- How to create a rich set of behaviors ?
- How to direct avatars ?
- How to animate avatar motion ?



# **Related Work**

## **(Probabilistic/Statistical Models)**

### **Statistical models**

- **Bradley & Stuate 97**
- **Brand & Hertzmann 00**
- **Pullen & Bregler 00**
- **Bowden 00**
- **Galata, Johnson & Hogg 01**
- **Li, Wang & Shum 02**

### **Search and playback original motion data**

- **Molina-Tanco & Hilton 00**
- **Pullen & Bregler 02**
- **Arikan & Forsyth 02**
- **Kovar, Gleicher & Pighin 02**
- **This work**

# Motion Database

## In video games

- Many short, carefully planned, labeled motion clips
- Manual processing



Walk Cycle



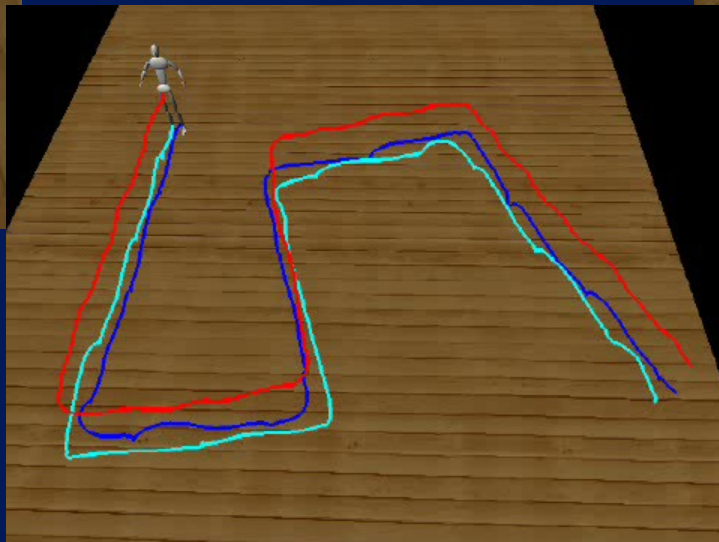
Start



Stop



Left Turn



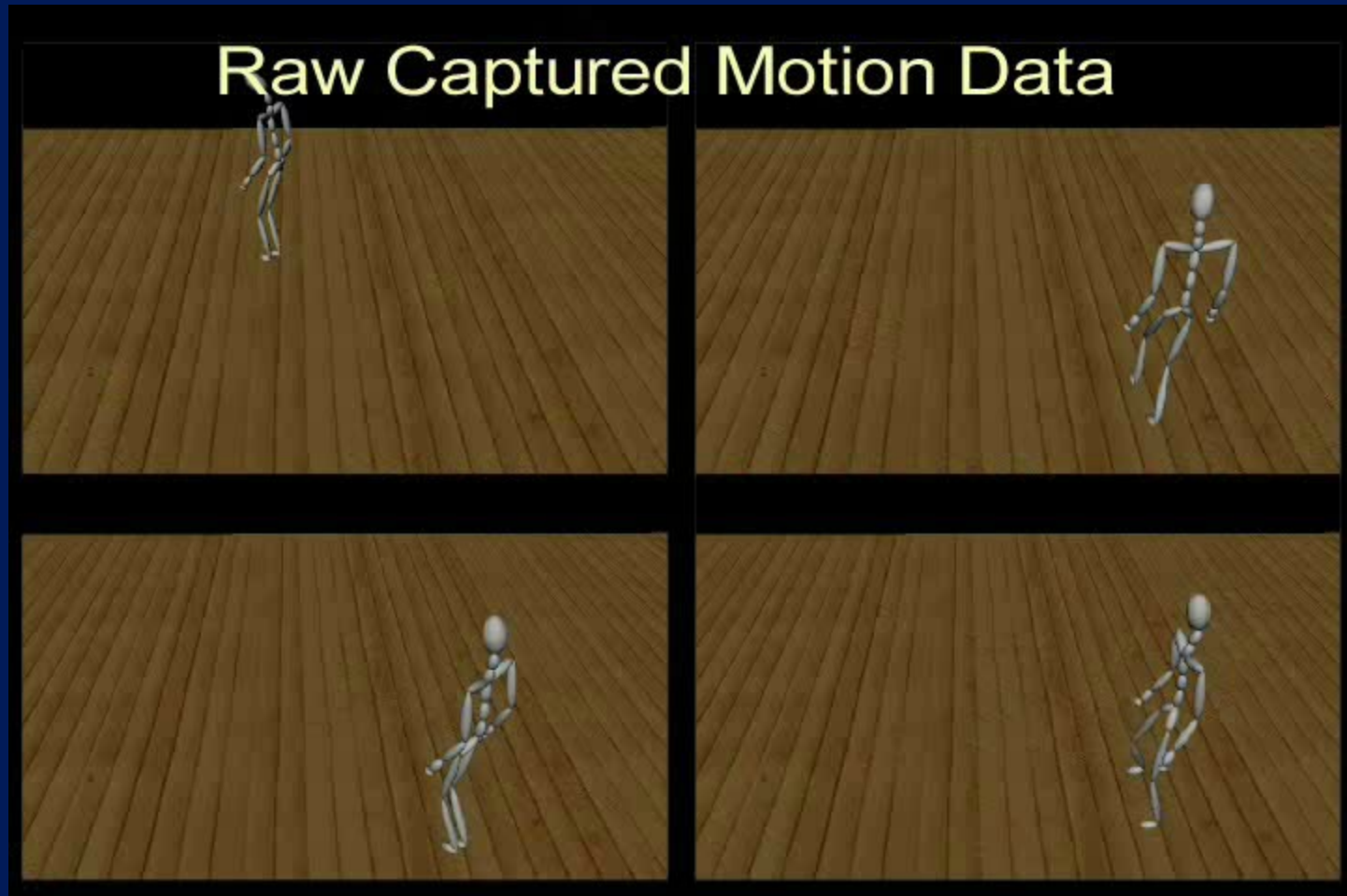
Right Turn

# Motion Database

## Our approach

- Extended, unlabeled sequences
- Automatic processing

# Motion Data Acquisition





# Maze - Sketch Interface

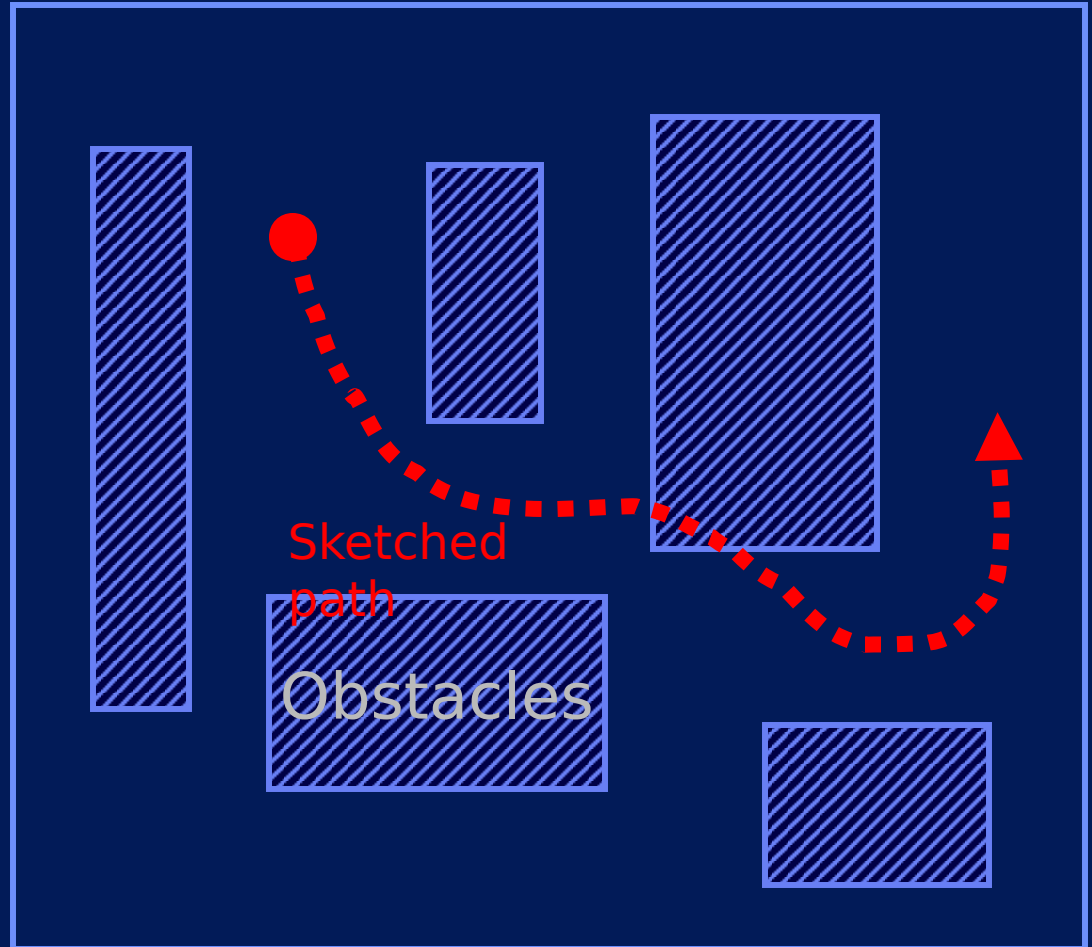


# Re-sequence

Motion capture  
region

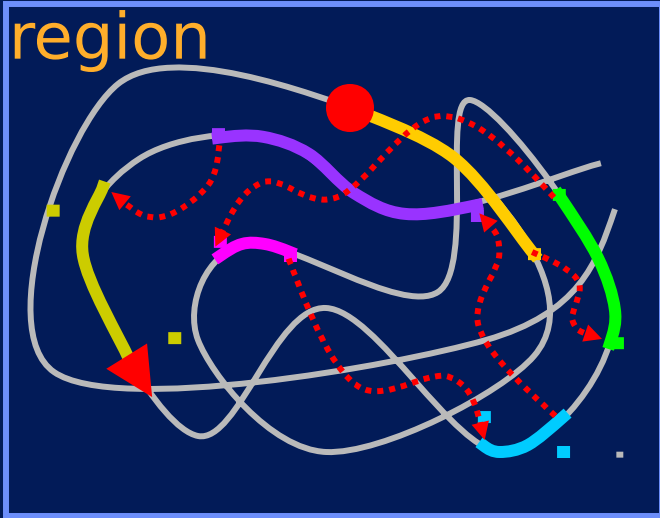


Virtual environment

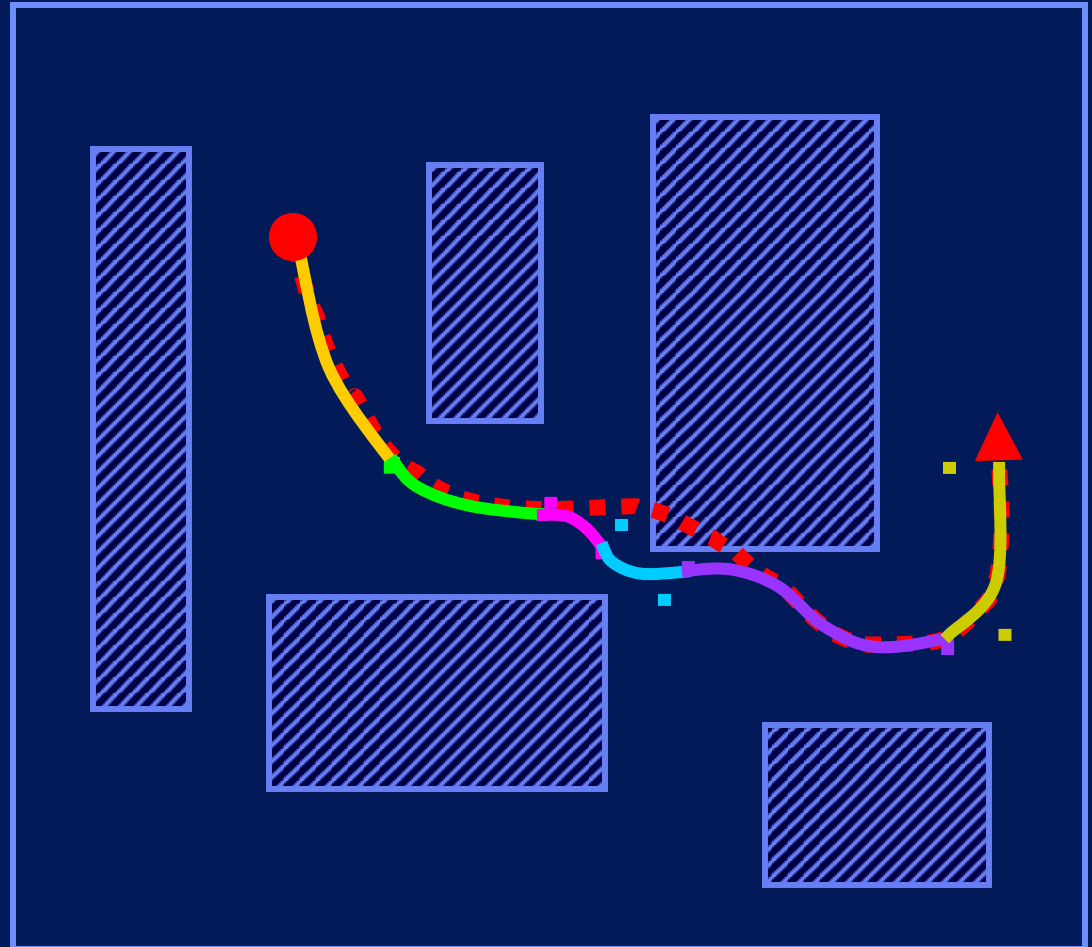


# Re-sequence

Motion capture  
region



Virtual environment

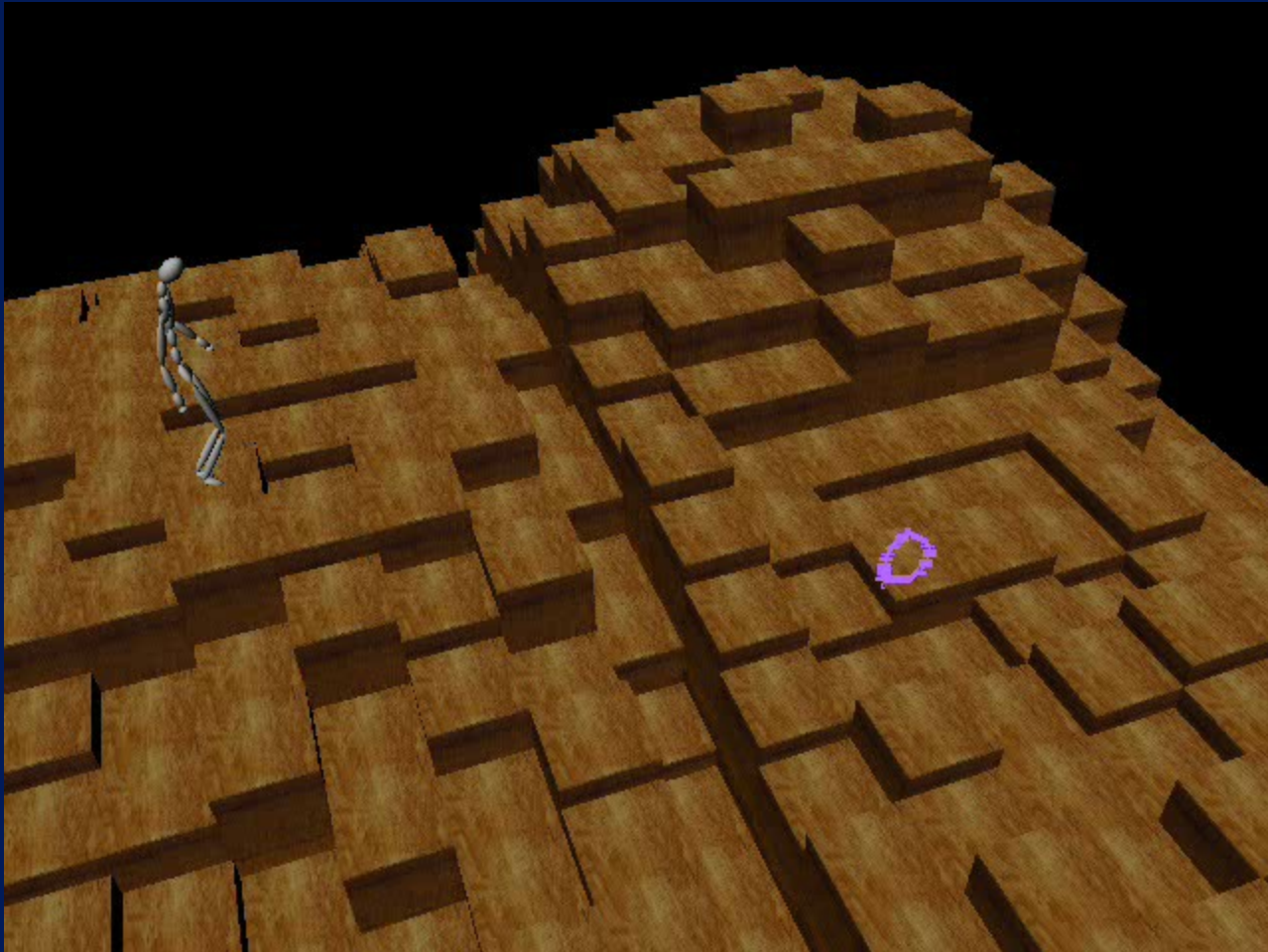


# Data Acquisition

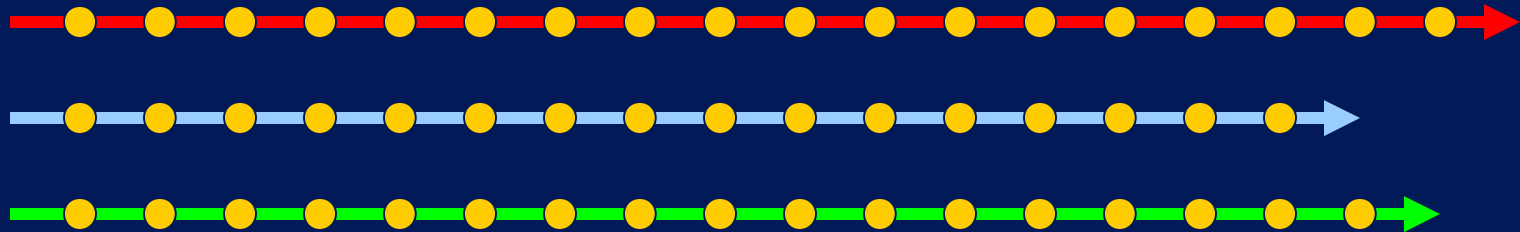
**“Poles and Holes” rough terrain**



# Terrain Navigation



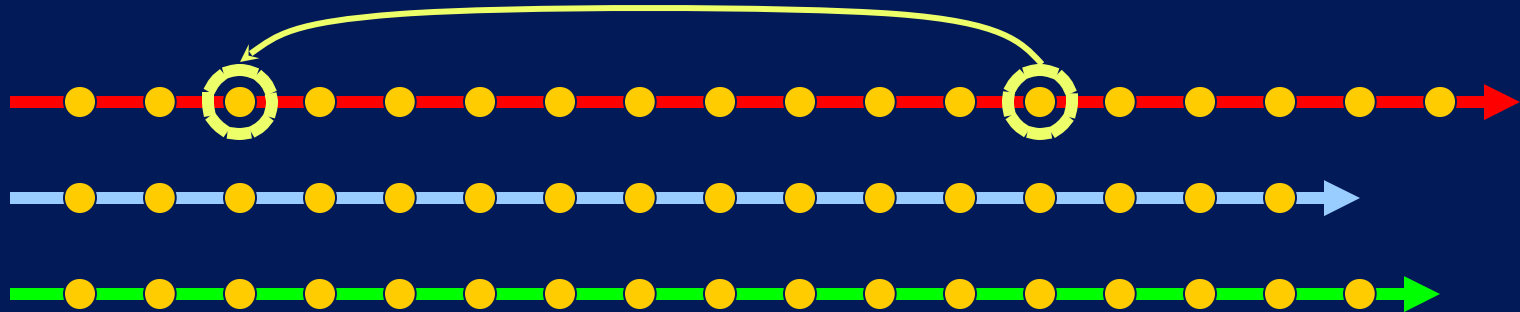
# Unstructured Input Data



## A number of motion clips

- Each clip contains many frames
- Each frame represents a pose

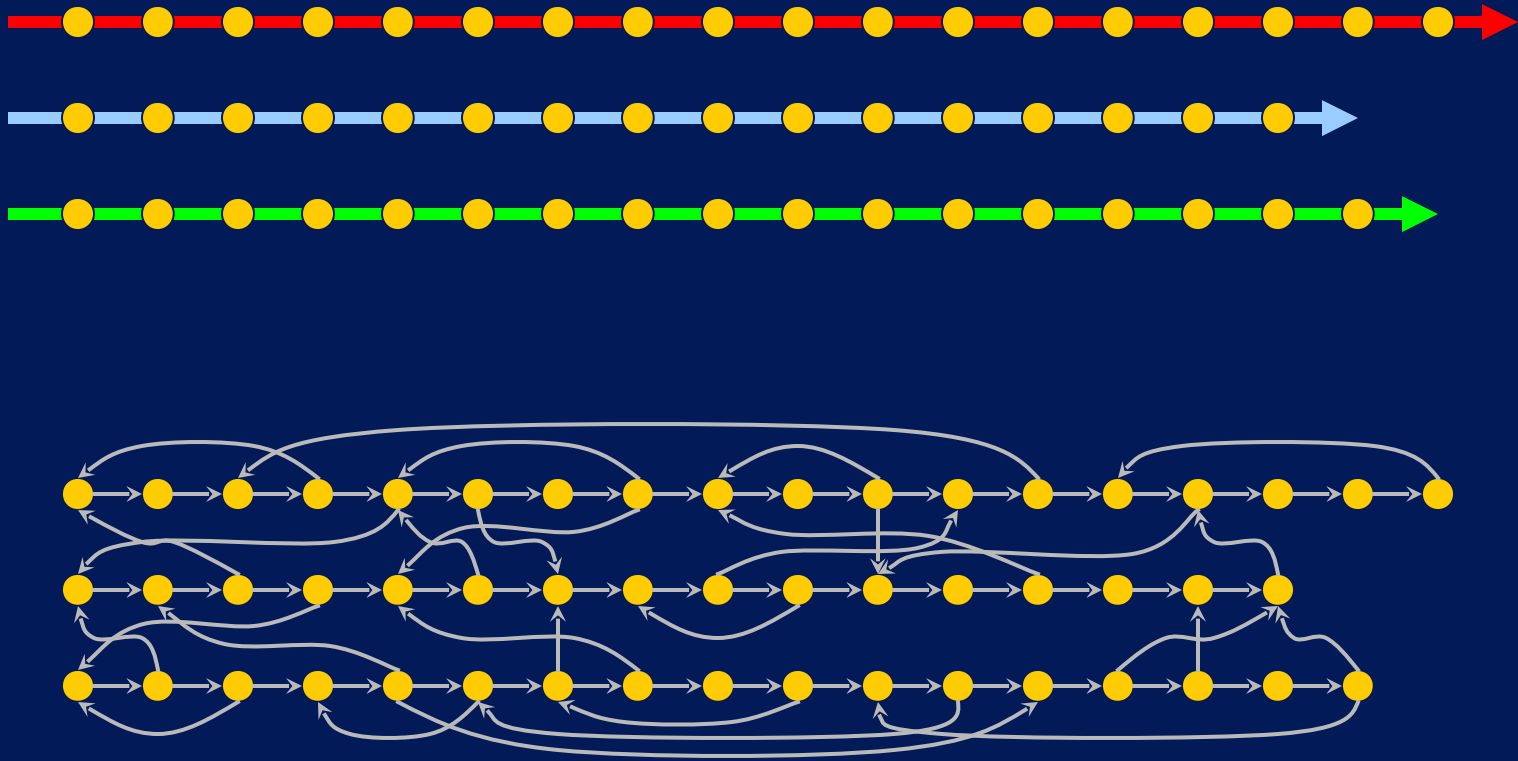
# Unstructured Input Data



## Connecting transition

- Between similar frames

# Graph Construction





# Distance between Frames

$$D(i, j) = \underbrace{d(p_i, p_j)}_{\text{Weighted differences of joint angles}} + \alpha \underbrace{d(v_i, v_j)}_{\text{Weighted differences of joint velocities}}$$

Weighted differences  
of joint angles

Weighted differences  
of joint velocities



# Pruning Transitions

## Reduce storage space

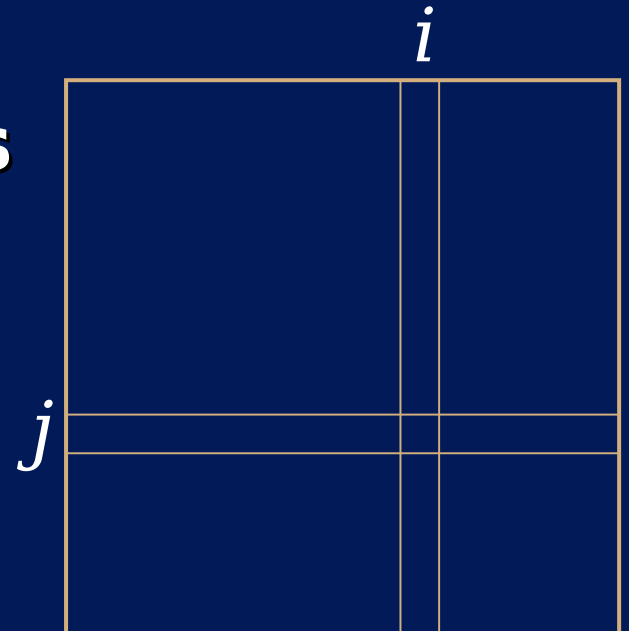
- $O(n^2)$  will be prohibitive

## Better quality

- Pruning “bad” transitions

## Efficient search

- Sparse graph



# Pruning Transition

- **Contact state:** Avoid transition to dissimilar contact state
- **Likelihood:** User-specified threshold
- **Similarity:** Local maxima
- **Avoid dead-ends:** Strongly connected components

# Graph Search

## Best-first graph traversal

- Path length is bounded
- Fixed number of frames at each frame

## Comparison to global search

- Intended for interactive control
- Not for accurate global planning

# Comparison to Real Motion

**Environment with physical obstacles**

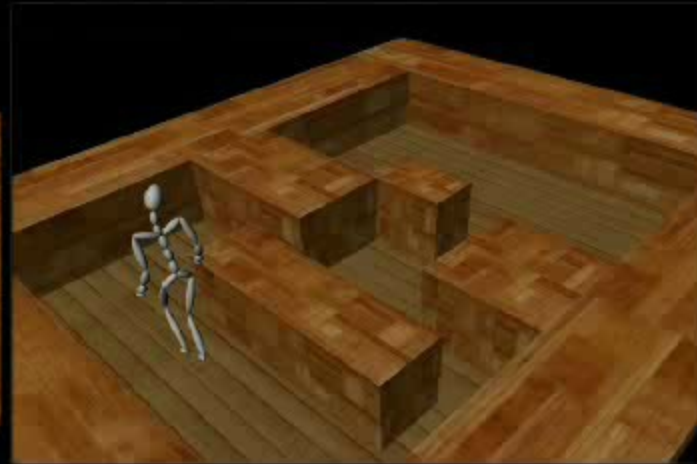


# Comparison to Real Motion

**Synthesized**

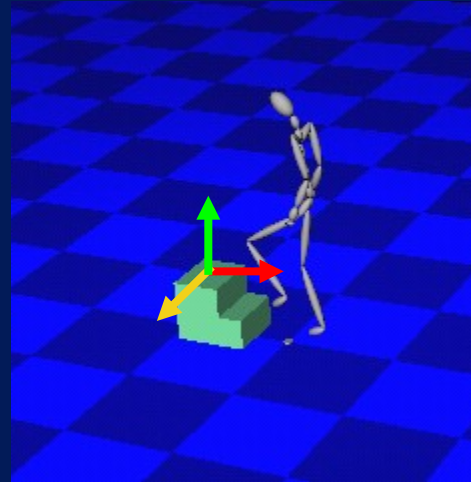


**Recorded**

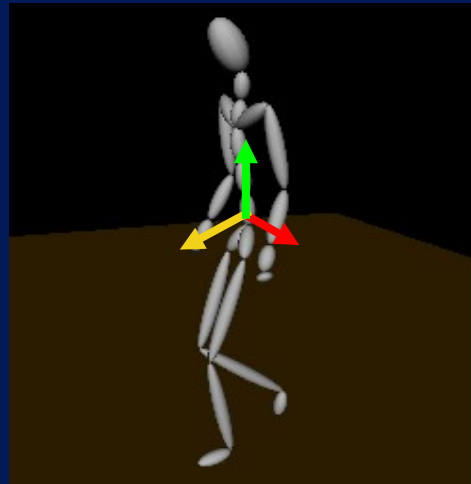


# Global vs. Local Coordinates

**Global, fixed,  
object-relative  
coordinates**



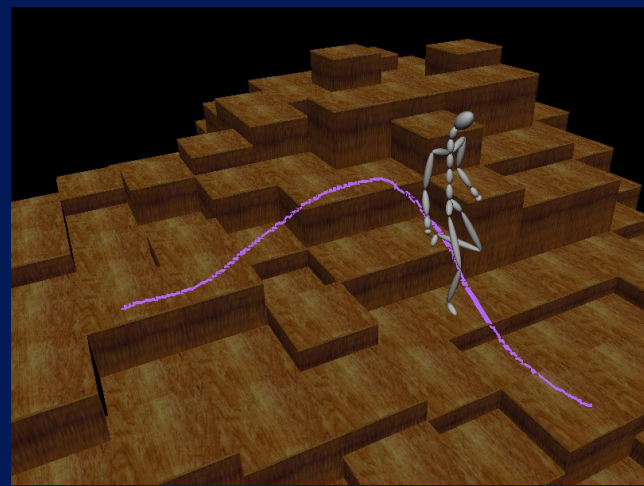
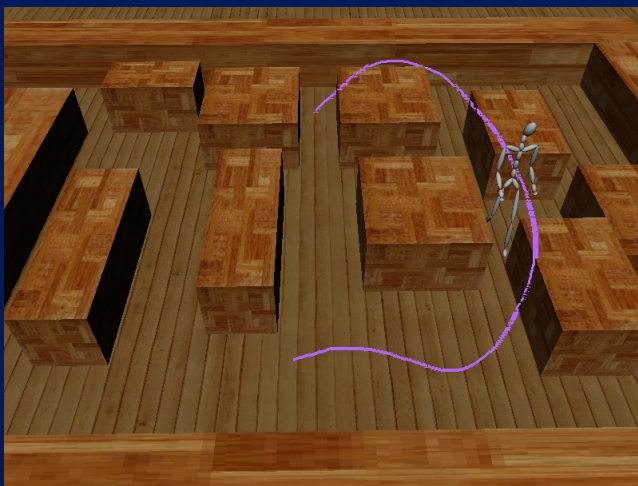
**Local, moving,  
body-relative  
coordinates**



# User Interface

## In maze and terrain environments

- Sketch interface was effective





# User Interface

## In playground

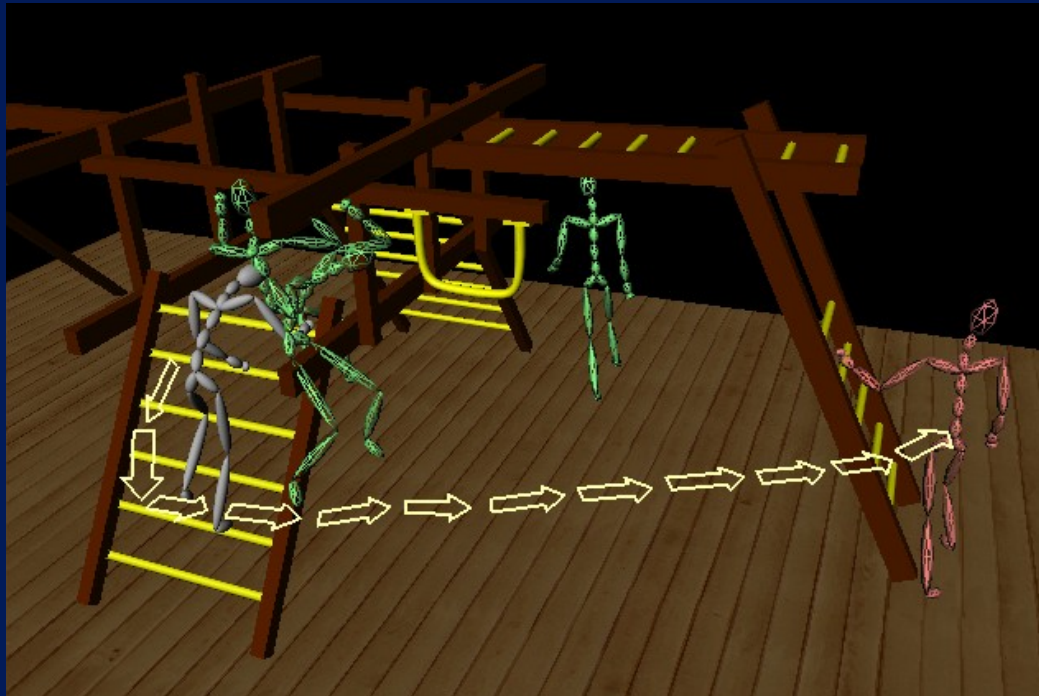
- A broader variety of motions are available



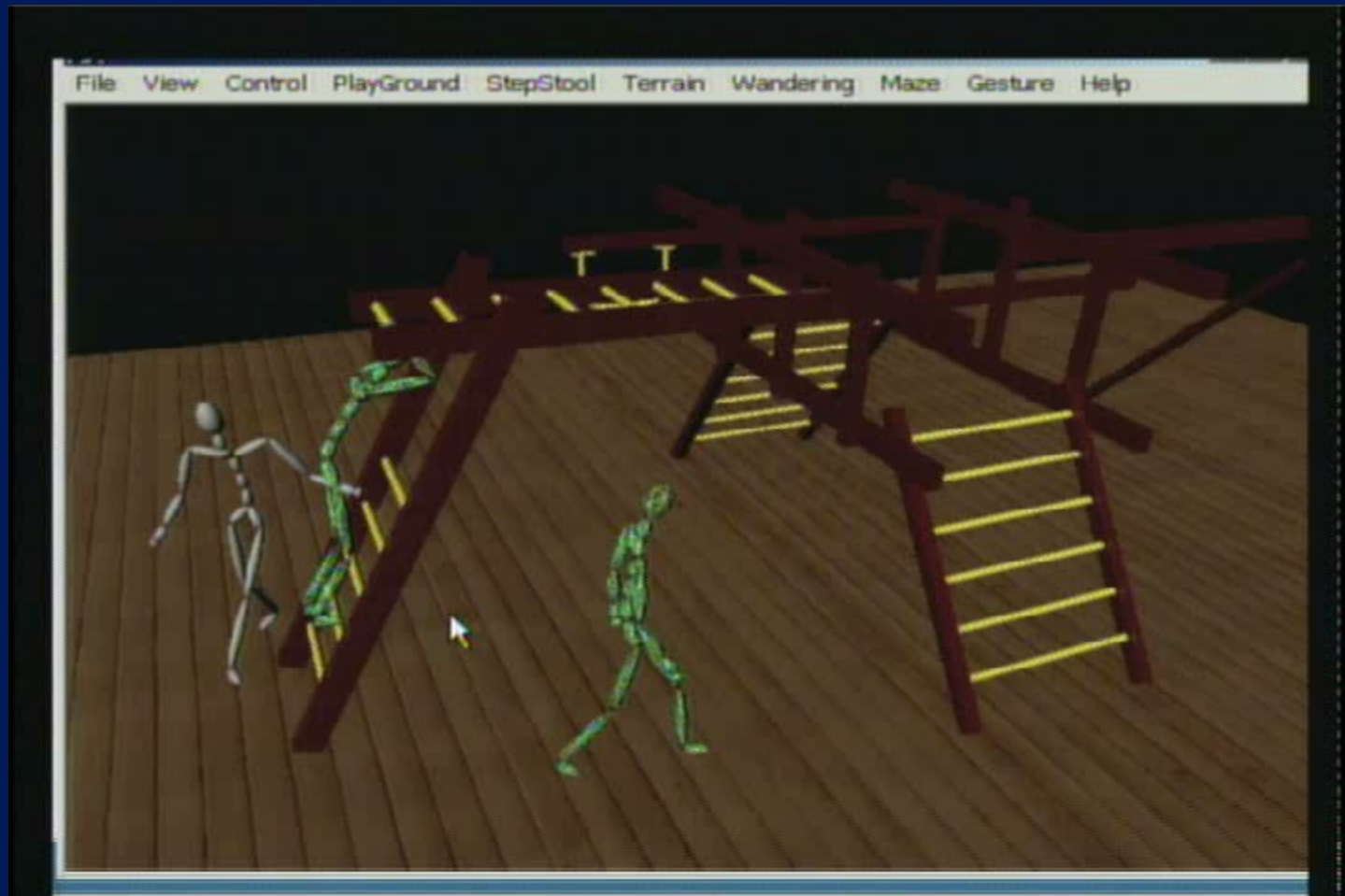
# Choice Interface

## What is available in database ?

- Provide with several options
- Select among available behaviors

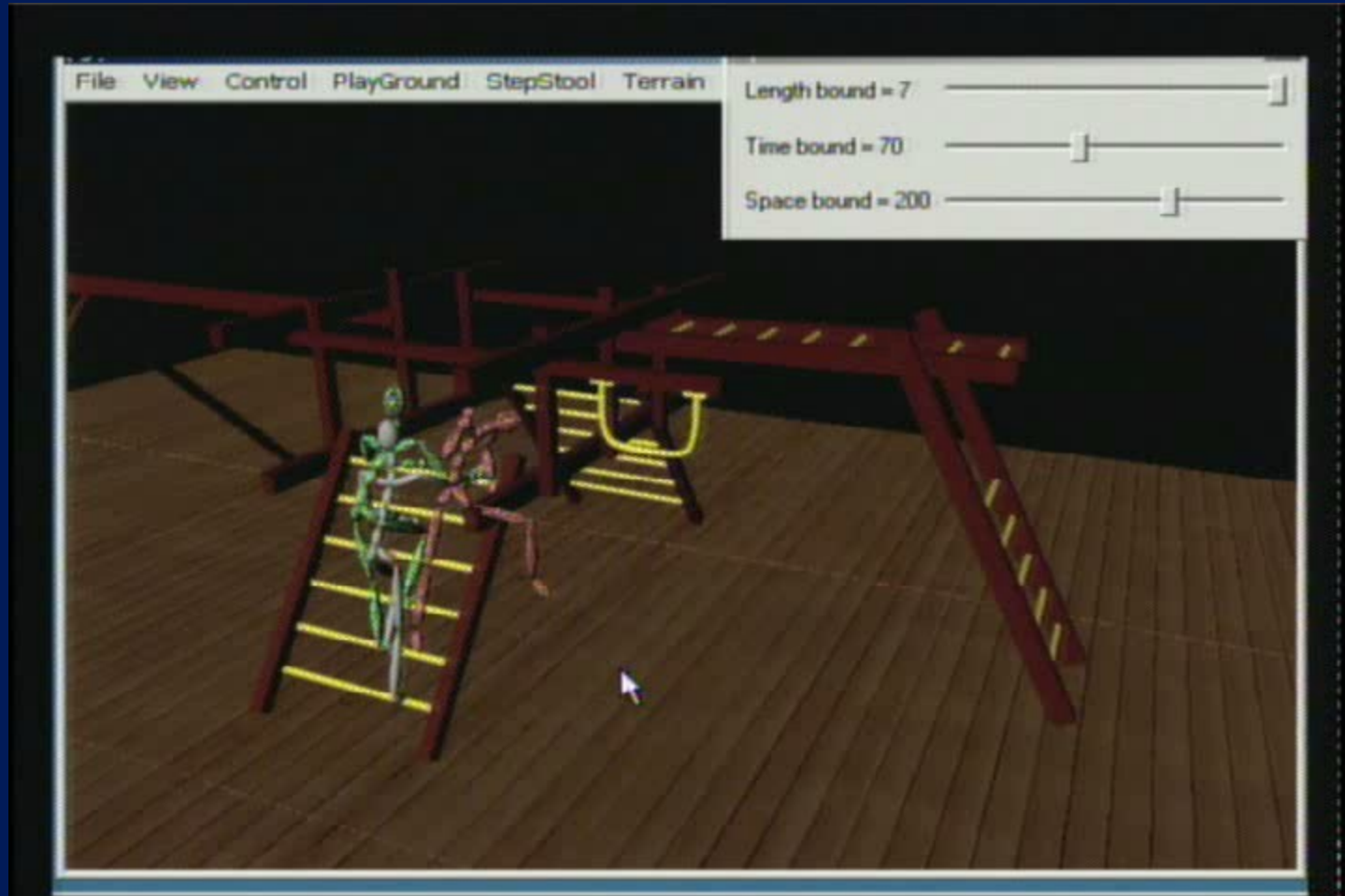


# Choice Interface

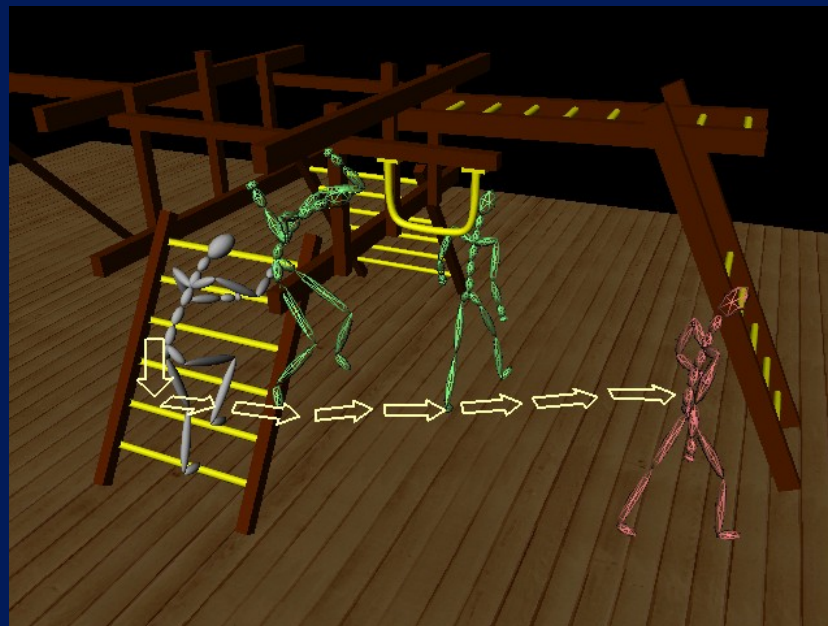
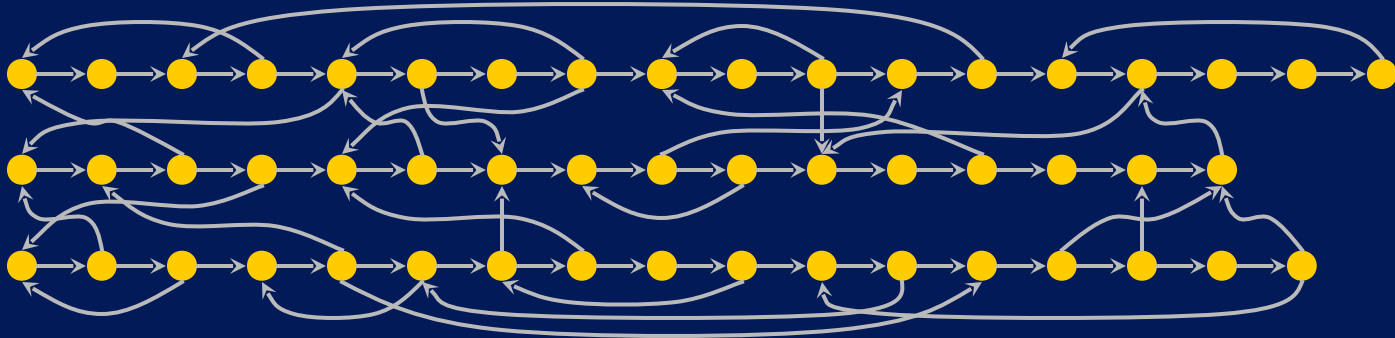


# What to Show

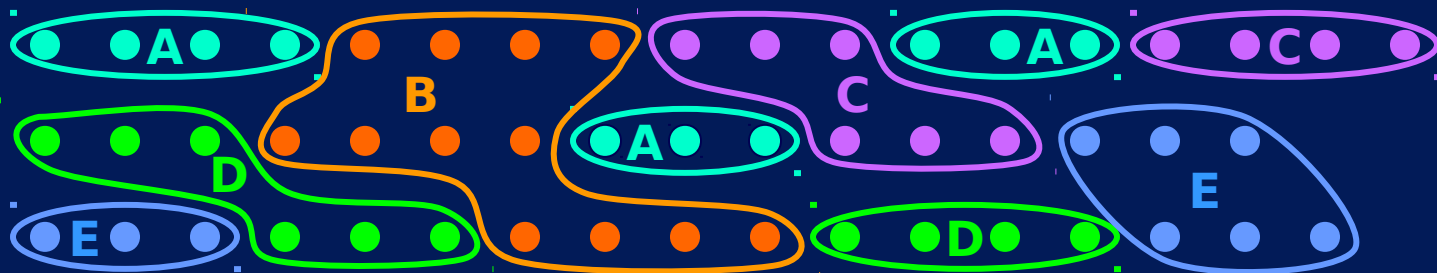
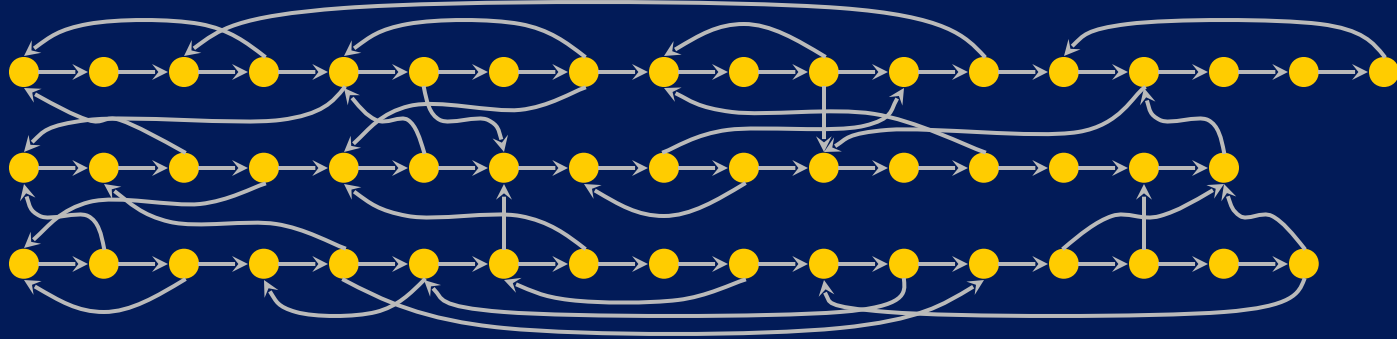
## Space and Time Windows



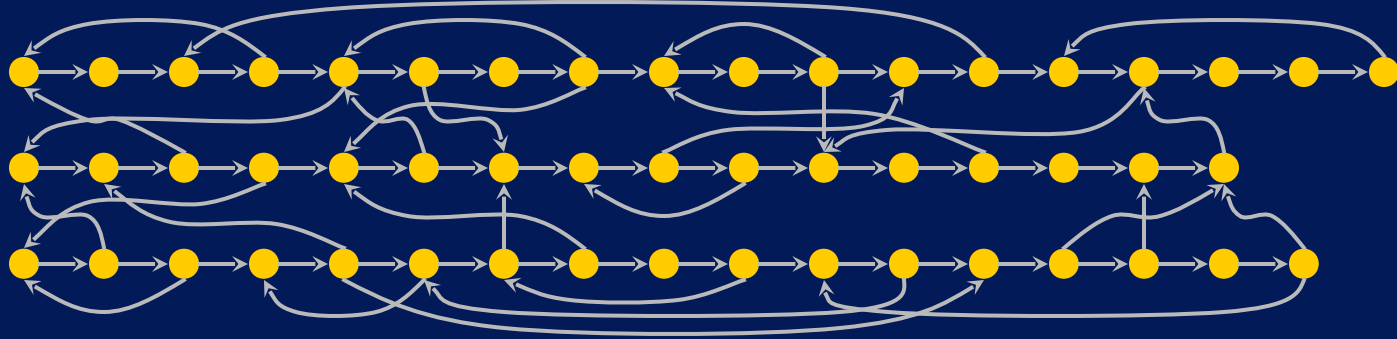
# How to Create Choices



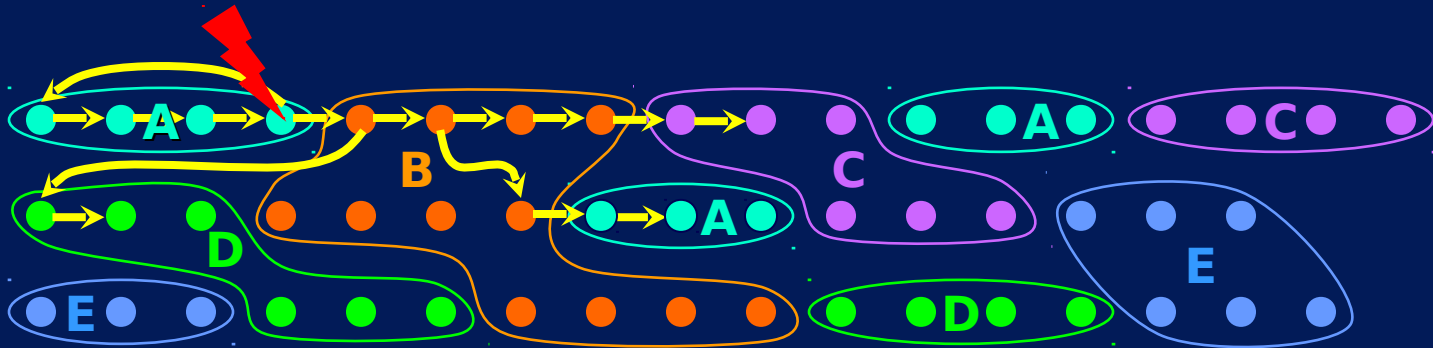
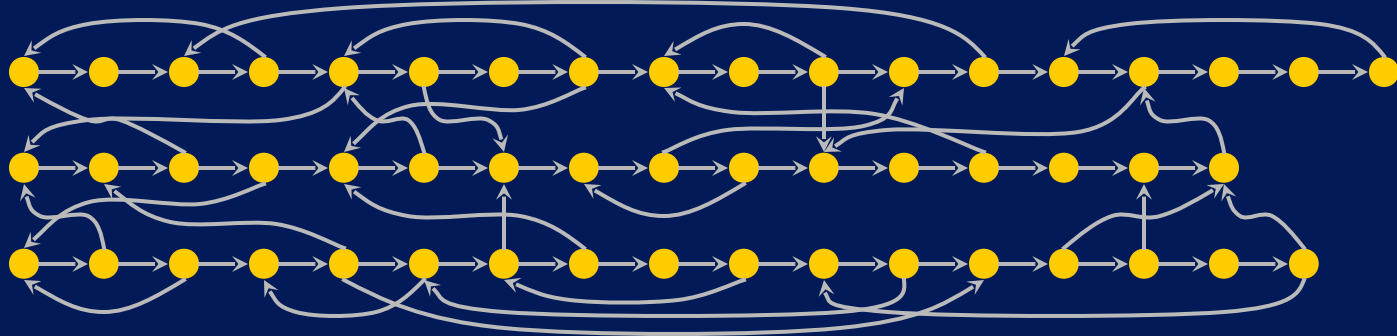
# Clustering



# How to Capture Transitions



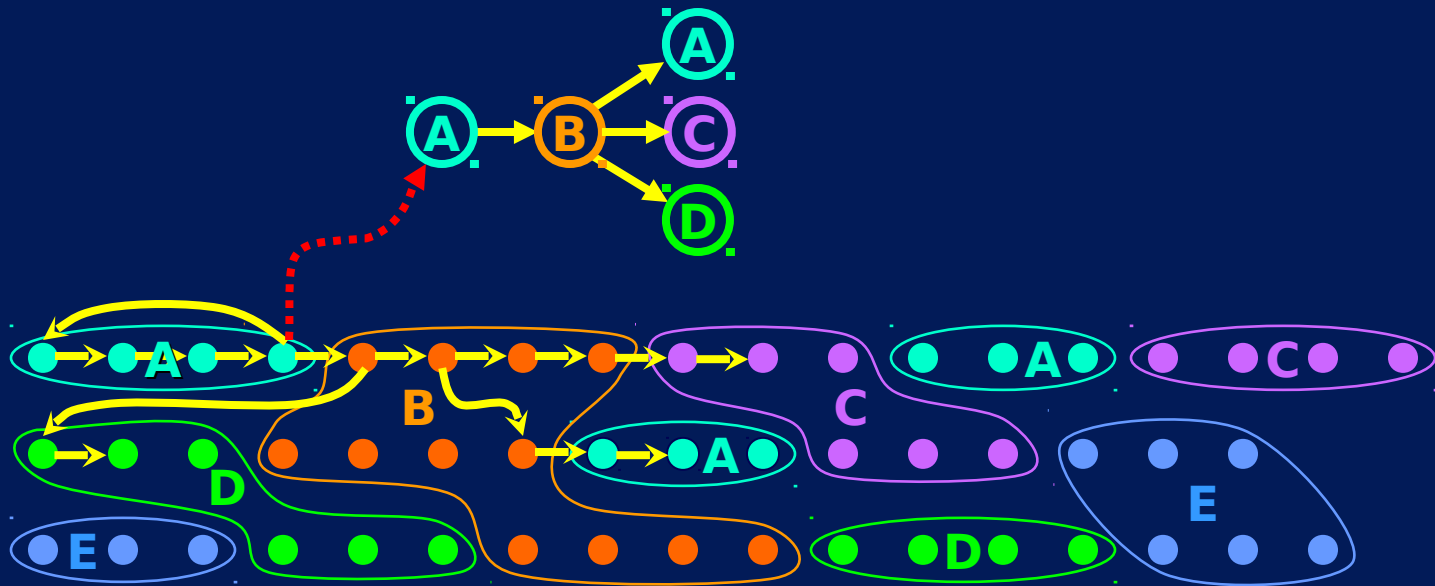
# How to Capture Transitions



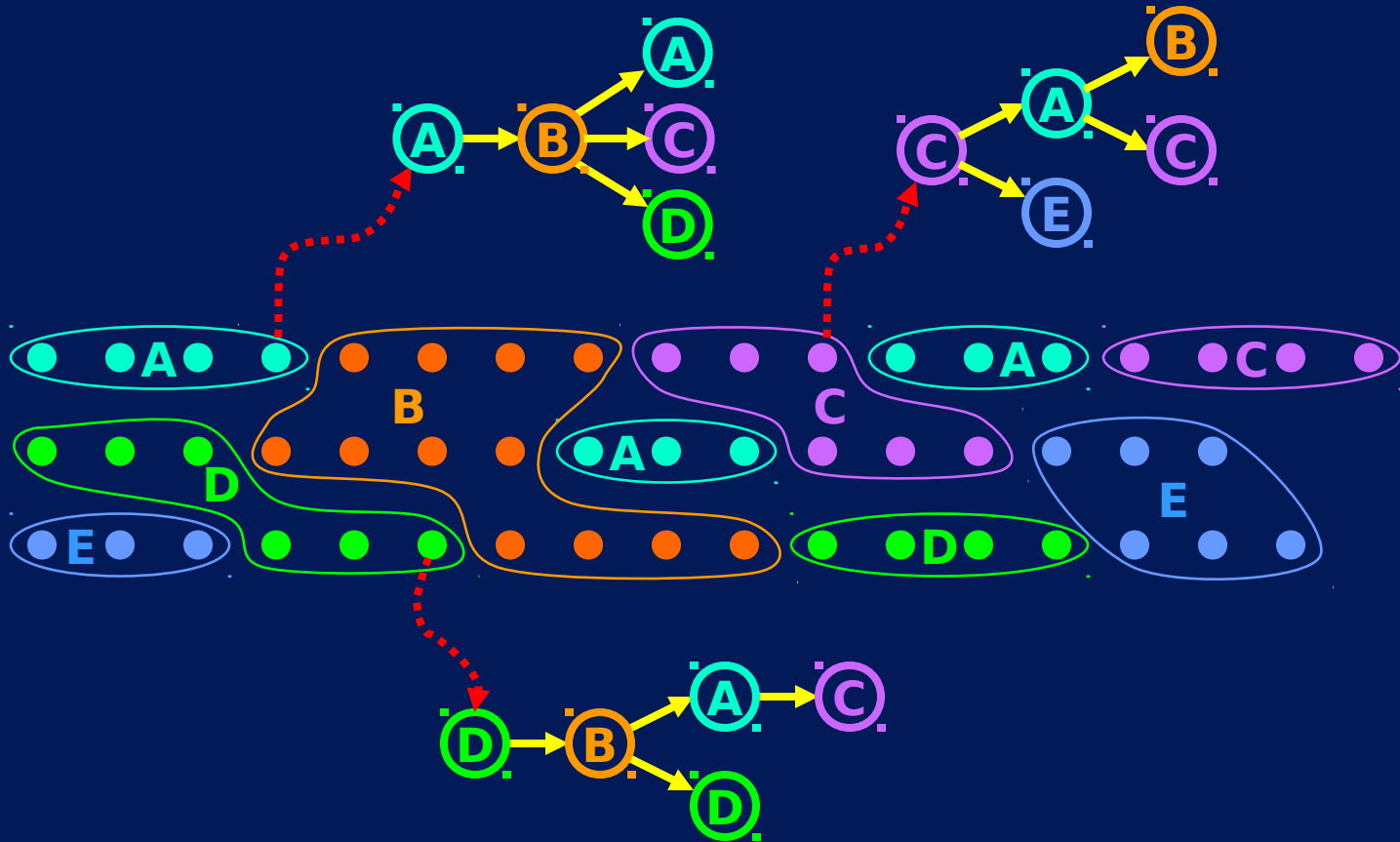


# Cluster Tree

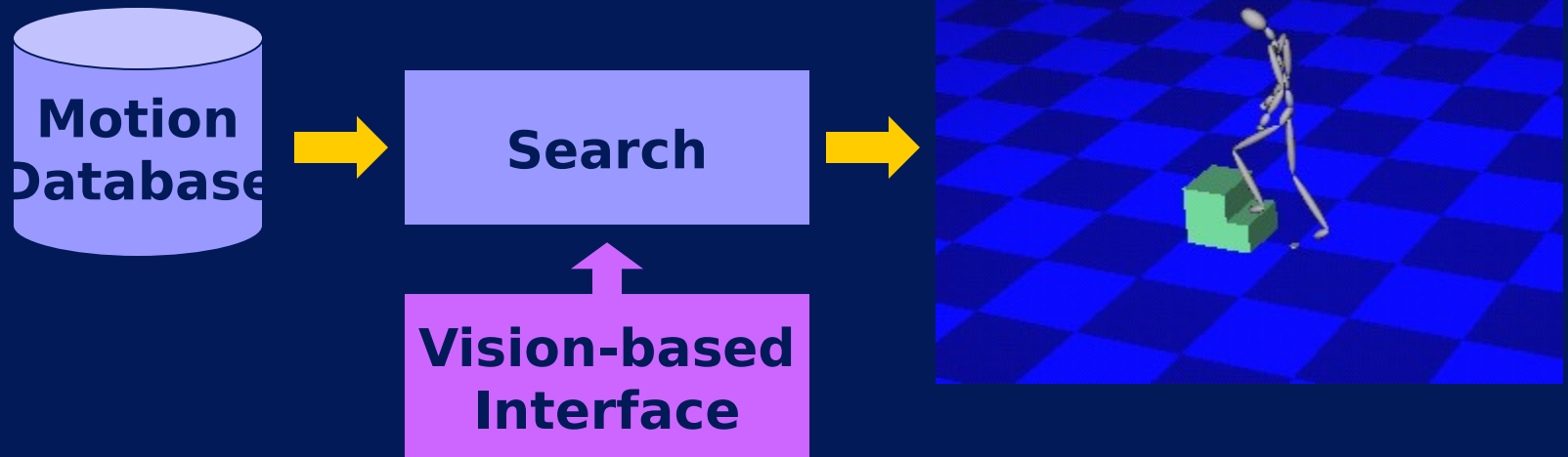
**Three possible actions: ABA, ABC, ABD**



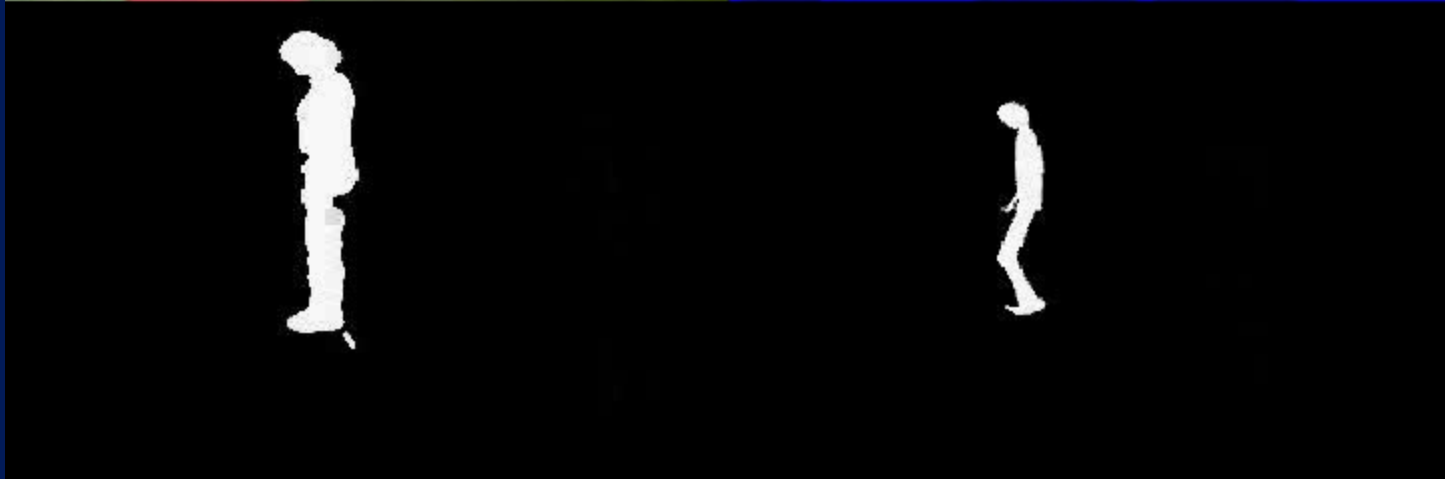
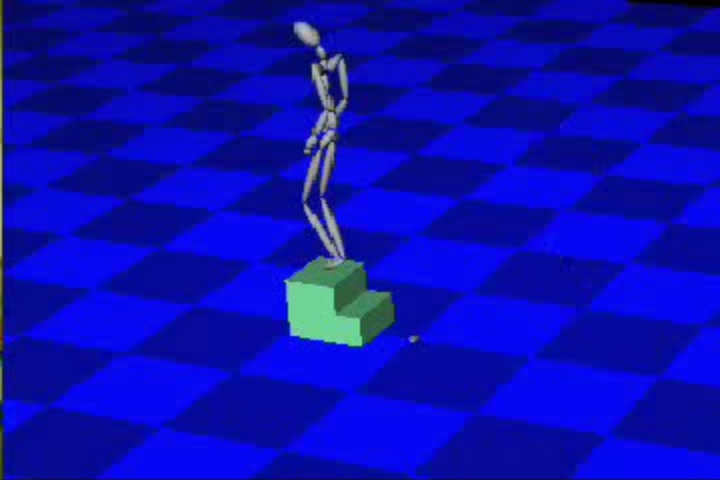
# Cluster Forest



# Performance Interface



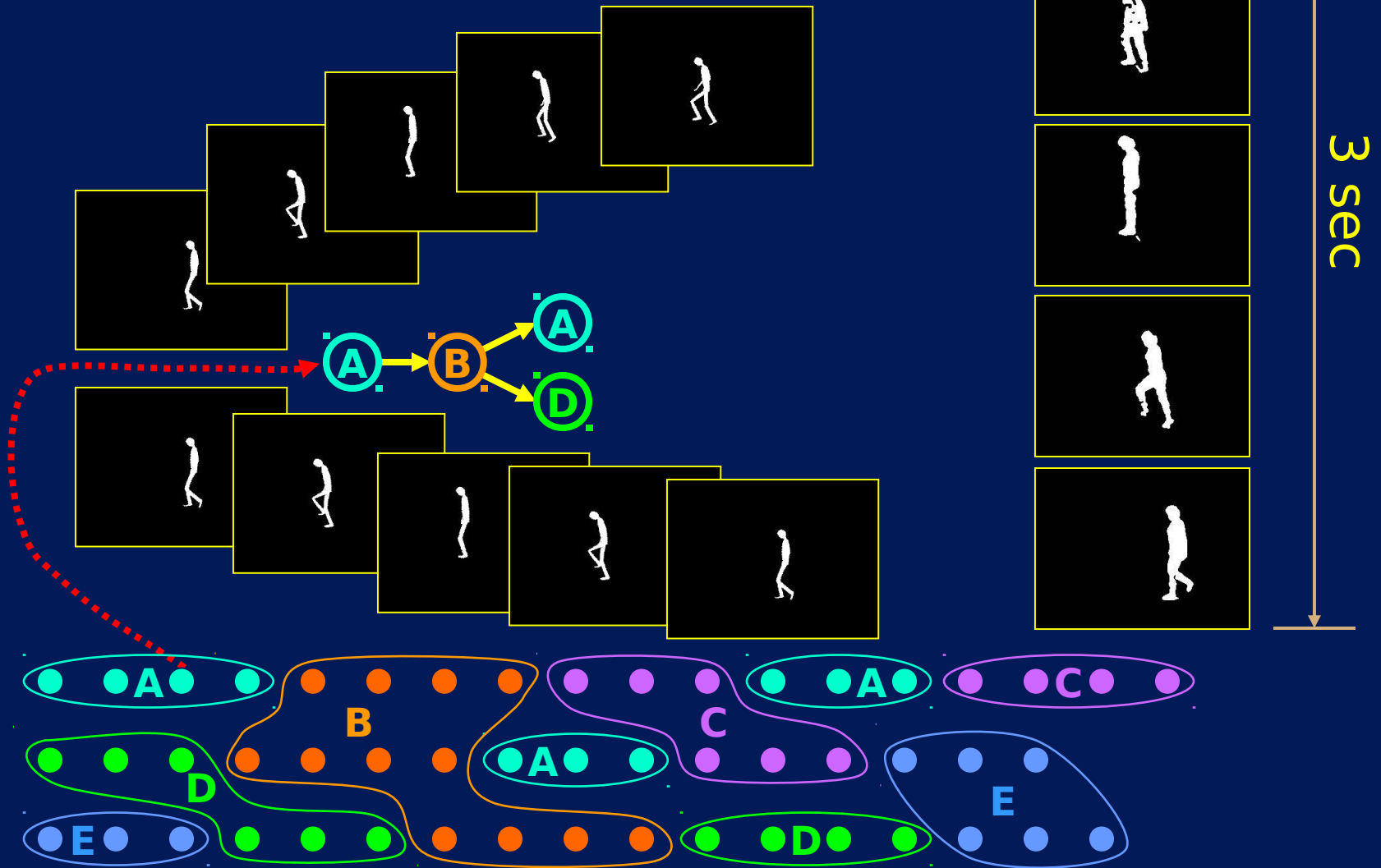
# Vision Interface - Single Camera



# Search



# Search



# Summary

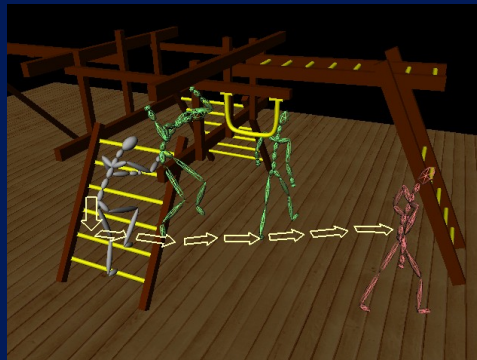
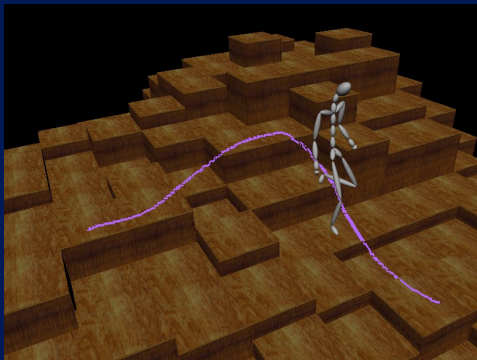
## Graph representation

- Flexibility in motion

## Cluster forest

- A map for avatar's behavior

## User interfaces



# **Future Work**

## **Body-relative vs. object-relative**

- **Assemble objects in new configurations**
- **Interactions among avatars**

## **Evaluate user interface**

- **User test for effectiveness**

## **Combine with existing techniques**

- **Motion editing and style modifications**



# Acknowledgements

## Thank

- All of our motion capture subjects
- Rory and Justin Macey

## Support

- NSF

## Project web page

<http://graphics.snu.ac.kr/~jehee/Avatar/avatar.htm>



# Similarity between Frames

	Our Work	Arikan & Forsyth	Kovar & Gleicher & Pighin
Joint Angle/Position	Angle	Position	Position
Pose	O	O	O
Velocity	O	O	Implicitly
Acceleration	X	Translation Only	Implicitly

# Pruning Transitions

	Our Work	Arikan & Forsyth	Kovar & Gleicher & Pighin
Contact	O	X	X
Likelihood	O	O	O
Similarity	O	X	O
Avoid dead ends	O	X	O

# Related Work (Character Animation)

<b>Rule-based</b>	<b>Control system</b>
<b>Bruderlin &amp; Calvert 96</b> <b>Perlin &amp; Goldberg 96</b> <b>Chi et al. 00</b> <b>Cassell et al. 01</b>	<b>Hodgins et al. 95</b> <b>Wooten and Hodgins 96</b> <b>Laszlo et al. 96</b> <b>Faloutsos et al. 01</b>
<b>Example-based</b>	<b>Probabilistic/Statistical Models</b>
<b>Popovic &amp; Witkin 95</b> <b>Bruderlin &amp; Willams 95</b> <b>Unuma et al. 95</b> <b>Lamouret &amp; van de Panne 96</b> <b>Rose et al. 97</b> <b>Wiley &amp; Hahn 97</b> <b>Gleicher 97, 98, 01</b> <b>Sun &amp; Mataxas 01</b>	<b>Bradley &amp; Stuart 97</b> <b>Pullen &amp; Bregler 00, 02</b> <b>Tanco &amp; Hilton 00</b> <b>Brand &amp; Hertzmann 00</b> <b>Galata &amp; Johnson &amp; Hogg 01</b> <b>Arikan &amp; Forsyth 02</b> <b>Kovar &amp; Gleicher &amp; Pighin 02</b> <b>Li &amp; Wang &amp; Shum 02</b> <b>(THIS WORK)</b>

# Related Work (User Interfaces)

<b>Graphical User Interfaces</b>	<b>Performance (Motion capture devices)</b>	<b>Performance (Vision-based)</b>
<b>Bruderlin &amp; Calvert 96</b> <b>Laszlo et al. 96</b> <b>Rose et al. 97</b> <b>Chi et al. 00</b>	<b>Badler et al. 93</b> <b>Semwal et al. 98</b> <b>Blumberg 98</b> <b>Molet et al. 99</b> <b>“Mocap Boxing” (Konami)</b>	<b>Blumberg &amp; Galyean 95</b> <b>Brand 99</b> <b>Rosales et al. 01</b> <b>Ben-Arie et al. 01</b>